Suppressing Abnormal Discharges in Plasma Processes

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All plasma processes share a common problem that affects yield. Abnormal electric discharges can create particulate matter and cause physical and/or electrical damage to the wafer. Such discharges can also cause the resulting plasma to be unstable.

A group of researchers determined that they could effectively detect and suppress anomalous discharges in plasma equipment using the signals from two probes that can predict the occurrence of abnormal discharges. The discharges are then suppressed by the voltage applied to the electrostatic chuck in a reactive ion etch (RIE) system. Repor findings at the recent IEEE International Symposium on Semiconductor Manufacturing were M. Yasaka (currently at the Ariake National College of Technology in Fukuoka, Ja colleagues with the Tokyo Cathode Lab (Kumamoto, Japan), NEC Electronics, the Kun Industrial Research Institute and the Kyushu Institute of Technology .

The researchers used two sensors: an acoustic emission (AE) sensor and a view-port (The VP probe was specifically designed for this application and is able to detect chang potential just prior to anomalous electrical discharge. The AE sensor detects the acous emitted from the point where the discharge occurred. The detection of a supersonic wa independent of plasma generation method (DC or RF).

The VP probe uses a transparent electrode film made of indium tin oxide, which is posi between the inner, thin quartz glass and the outer, thick glass of the RIE system's view probe detects a difference in charge buildup at the inner glass surface of the viewing pc detectors are able to monitor the occurrence of abnormal discharge, and can also be u the location of the discharge by analyzing the acoustic signals detected by multiple AE attached at different locations inside the process tool. The AE sensor was attached to t of the RIE tool with three AE sensors located around the periphery of the chamber. The used an in situ particle monitoring system capable of detecting titanium particles >70 nr

The parallel-plate RIE system used 13.56 MHz excitation voltage, and anomalous disch induced using moisture on a titanium-coated wafer mounted on the RF electrode by an chuck (ESC) with helium backside cooling. RF power of 1000 W was supplied. Gases c were used. The discharge pressure was 30 Pa. The researchers monitored the AE and sensor signals using a multichannel digital data recorder.

Monitoring showed the VP probe was very sensitive to change in electrical potential, sh

negative output voltage (Figure). This indicates that the flux of electron flow from the pl increased at the moment that the anomalous discharge occurred. The anomalous disch a plasma state where the plasma density and/or electron temperature was higher than state. The AE sensor detected the change in potential just milliseconds after the VP prc indicating the propagation delay of the AE wave along the chamber wall.

Signal waveform of the view-port probe shows that the indicating signal appears prior to the anomalous discharges.

Moisture in the chamber caused abnormal discharges to occur ~3 sec apart for 10 min. wafer was replaced with another wafer with moisture, the same phenomena occurred. S the particle monitor were coincident with the AE sensor and VP probe signals.

The group determined that, by lowering the voltage applied to the ESC wafer stage, fev discharges occurred. Therefore, they developed an electric feedback system that contr voltage using the foreseeing signal as a trigger. The system consists of an A/D convert the ESC voltage and an electronic system that records the discharge signals and analy position of the abnormal discharge points.

The feedback system responds to the foreseeing signal of the VP probe and applies vo ESC. When the ESC voltage control is employed, the anomalous discharge is complete suppressed.

Find more information on yield management.